International Journal of Advances in Engineering and Management (IJAEM)
Volume 6, Issue 10 Oct. 2024, pp: 96-103 www.ijaem.net ISSN: 2395-5252

# Broadcast Storm Mitigation Technique for Cluster Based (Bsmt_Cb) In Vanet

Abubakar Aminu Muazu[1], Salisu Musbahu[2]
*[1,2]Umaru Musa Yar'adua University, Computer Science Department*

Date of Submission: 05-10-2024 Date of Acceptance: 15-10-2024

**ABSTRACT:** This research proposes a novel clustering algorithm, Broadcast Storm Mitigation Technique for Cluster Based (BSMT_CB) in VANET (BSMT_CB), to address the broadcast storm problem in VANETs. BSMT_CBeffectively groups vehicles based on their relative mobility and selects a minimal number of cluster heads and gateways to ensure efficient message dissemination. By utilizing a dominating set and set cover approach, the algorithm achieves cluster stability and significantly reduces redundant rebroadcasts.

Simulation results demonstrate the superior performance of BSMT_CBin terms of message delivery delay, packet loss ratio, packet delivery ratio, and throughput. BSMT_CB outperforms existing methods by reducing broadcast storms, enhancing message reachability, and ensuring efficient message dissemination even in dense traffic conditions. The proposed algorithm offers a promising solution for improving the efficiency and reliability of communication in VANETs.

**Keywords:** Vehicular Ad Hoc Networks (VANETs), Broadcast Storm Problem, Clustering Algorithm, Message Dissemination, Gateway Selection.

## I. INTRODUCTION

Vehicular Ad hoc Networks (VANETs) are a type of wireless network designed to allow vehicles to communicate with each other and with roadside infrastructure, such as traffic signals and sensors. VANETs have the potential to improve road safety, reduce traffic congestion, and provide a platform for new applications and services, such as autonomous driving and infotainment. The study of VANETs is a multidisciplinary field that combines expertise in wireless communication, computer networking, and transportation engineering. Researchers in this field are concerned with developing communication protocols, routing algorithms, and network architectures that can support reliable and efficient communication among vehicles and infrastructure (Al-Turjman, 2017).

Though the increase in the number of rebroadcasts enhances the reachability of the message to all vehicles of interest, it increases the delay due to higher collisions and retransmissions as well. Hence, the number of messages transferred in the network should be limited to reduce the network delay and congestion. For further rebroadcast, a subset of vehicles that receives the alert message should be selected to control the broadcast storm problem. The selection of such vehicles is achieved by grouping (clustering) the vehicles based on topology, density, distance, speed, location or a combination of these. The selection of cluster heads and gateways in cluster-based schemes have a significant impact on the number of rebroadcasts (Lin & Gerla, 2016).

For reducing the broadcast storm problem, a simple solution is to suppress the rebroadcast of the message to the extent possible without detecting the reachability of the message. Suppression of rebroadcasting can be achieved through selecting a limited number of next forwarders by grouping the vehicles into clusters and selecting the cluster heads and gateways in an efficient manner that ensures reachability. Hence, the research questions at hand are how to group the vehicles into clusters, how to select cluster head vehicle and gateway vehicles in a cluster in an efficient manner such that the number of rebroadcasting vehicles is reduced, but without reducing the reachability of the message.

Hence, this research work aims to design a new clustering algorithm that groups the vehicles based on dominating set and set cover to achieve an optimal number of cluster heads and gateway for each cluster in a fully distributed manner by considering the local neighborhood information and adapting an event-triggered approach that can achieve high reachability with reduced number of rebroadcasts.

## II. VANET TECHNIQUES

### a. The Concept of VANETS

VANETs are ad-hoc networks formed by moving vehicles and devices that wirelessly exchange information. Vehicles act as nodes in the network, sharing and receiving data. VANETs are open networks where vehicles can freely join and leave. New vehicles with on-board sensors can easily join the network. VANETs use various wireless technologies like DSRC, Cellular, Satellite, and WiMAX. They are part of Intelligent Transportation Systems (ITS). VANETs enable Vehicle-to-Vehicle (V2V) and Vehicle-to-Infrastructure (V2I) communication.

### b. VANET Techniques

**DSRC (Dedicated Short-Range Communication):** A wireless technology for V2V and V2I communication, operating on the 5.9 GHz frequency band. It offers low latency and high reliability, but is vulnerable to interference and jamming.

**IEEE 802.11p:** A wireless standard for VANETs based on Wi-Fi. It offers reliable and efficient communication, but has limitations like limited coverage and susceptibility to interference.

**WAVE (Wireless Access in Vehicular Environments):** An extension of IEEE 802.11p, providing enhanced security, network management, and mobility support.

**Sensor Networks:** Used to provide additional information about the environment, improving communication reliability and efficiency.

**Cellular Communication:** Offers wide coverage, high data rates, and robustness in urban areas, but may be less effective in low-visibility conditions and rural areas.

**Ad-hoc Networking:** Enables direct vehicle-to-vehicle communication without infrastructure, providing reliable communication in areas with limited infrastructure.

**High Mobility and Frequent Disconnections:** Dynamic network topologies due to vehicle movement make it difficult to ensure timely and reliable data dissemination.

**Data Transmission in Presence of Disconnections:** New vehicles entering the network may face challenges in receiving data before disconnecting, especially in high-density areas.

**Data Distribution over Mesh Nodes:** Disseminating data efficiently through a mesh network of roadside units can be complex.

**Broadcast Storm Problem (BSP):**

Broadcast communication is unreliable in VANET due to the lack of acknowledgements in CSMA/CA mechanism present in the IEEE 802.11p standard (G. Korkmaz et al, 2017). The vehicular safety application is improved by broadcasting a safety alert message in an emergent event for preventing the accidents or to give the prior intimation to the drivers about the dangerous situation (Q. Yu et al, 2018).

**Redundant Rebroadcasts:** Simple flooding techniques can lead to excessive message rebroadcasts, causing congestion and collisions.

**Contention and Collisions:** High traffic density and multiple nodes rebroadcasting the same message can create severe contention for the channel.

## III. STATEMENT OF THE PROBLEM

The broadcast storm problem is a significant challenge in VANETs, where excessive message rebroadcasting can lead to congestion and network inefficiency. Addressing this issue is crucial for the success of VANETs. Various approaches, including suppression techniques, rate control mechanisms, and power control strategies, have been proposed to mitigate the problem. This research focus on designing and testing algorithm to reduce the number of broadcasted messages and improve the efficiency of message dissemination in VANETs.

## IV. PROPOSED RESEARCH FRAMEWORK

The proposed framework of the enhanced algorithm is presented in this chapter as a form of chart in Figure 1. the enhancement starts by developing the E-CDCS algorithm, then the algorithm is simulated, after that the algorithm is implemented, after the implementation a decision is made either evaluating the results or modifying the existing algorithm, and then evaluating the results of the algorithm. Finally, validating the algorithm.

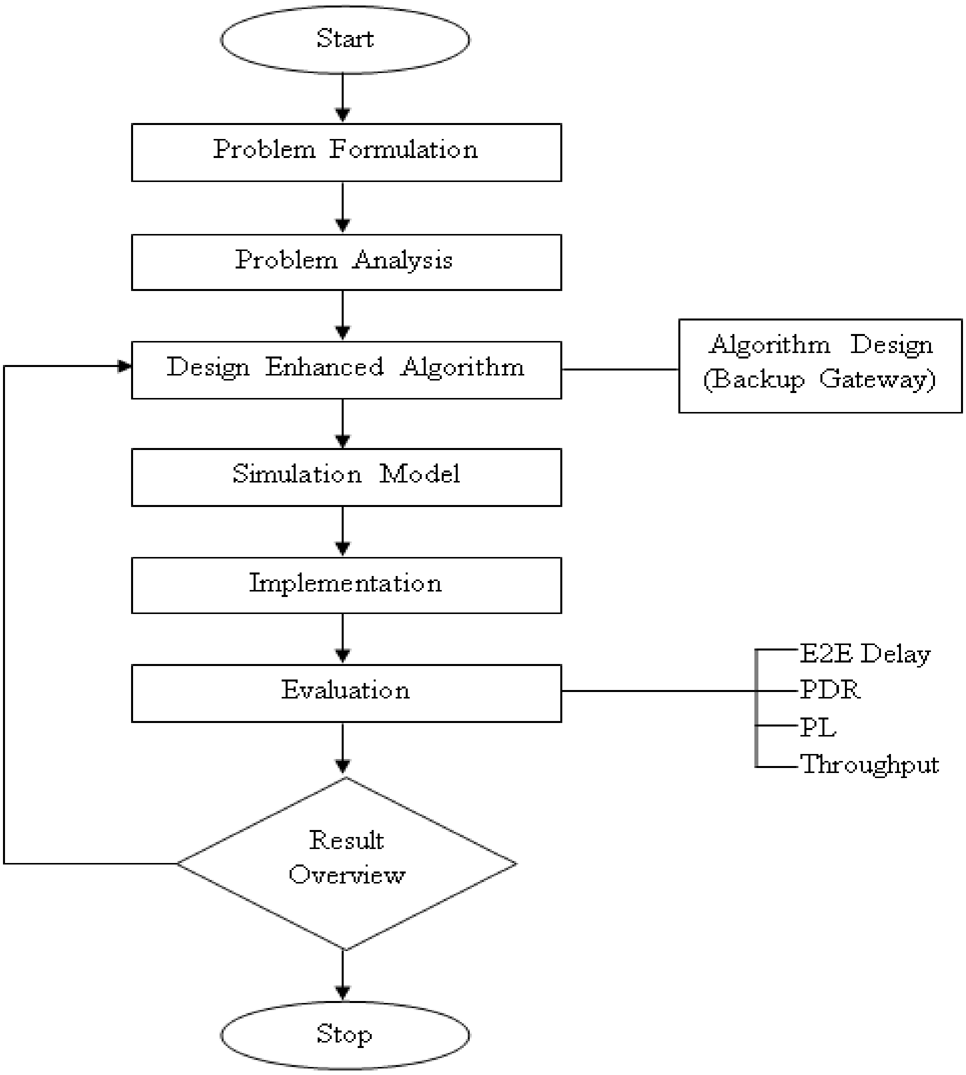

**Figure 1: Proposed Methodology**

### a. Network Scenario

The vehicle speeds varied from 7 m/s to 27 m/s. The performance of the protocol was measured in all two scenarios.

**Dense:** If the total number of vehicles moving in the same direction in all four lanes on the road per kilometer was between 31 and 50 (and above) it was considered a dense traffic scenario.

**Sparse:** If the total number of vehicles moving in the same direction in all four lanes on the road per kilometer was less than or equal to 15, then it was considered a sparse traffic scenario.

### b. NOTATIONS USED IN E-CDCS

The notations used to describe the proposed algorithm are presented in Table 1 below

**Table 1: Notations Used**

| Notation | Description |
|---|---|
| Id | Vehicle Ids |
| Dir | Direction of Movement of Vehicle |
| Color | State of Vehicle (white, black, blue, red, gold, yellow, gray) |
| $C_{id}$ | Set of all Neighbor Vehicles' Ids |
| S | Speed of Vehicle |
| CH | Cluster Head |
| GW | Gateway |

| | |
|---|---|
| $GW_{bp}$ | Backup Gateway |
| CCH | Candidate Cluster Head |
| CG | Candidate Gateway |
| $DC_u$ | Degree of Cohesion |
| $rm_{uv}$ | Relative Mobility Between Vehicle u and v |
| $d_{vu}$ | Distance between Vehicle u and v |

### c. Pseudocode

The proposed algorithm is an asynchronous event-driven model. All nodes start by running an initialization routine. When an event occurs, a node calls the corresponding routine based on its current status. Possible events include receiving a beacon message, missing a beacon message, changing status to Candidate Cluster Head, receiving messages from a Cluster Head or Candidate Gateway, or receiving a gateway selection message.

```
i. Initialization (Executed by All Nodes)
  1. colour = white
  2. $C_{id}$ = -1
  3. BackupGW = -1 (For storing Backup Gateway ID)
  4. Broadcast Beacon (id, s, dir, colour, $C_{id}$, BackupGW)
ii. Node 'u' Upon Receiving Beacon Message from Node 'v' (Executed by All Nodes)
  1. If dir = $dir_v$, then:
  2. If $v \notin N_u$, then $N_u = Nu \cup \{v\}$
  3. If colour = black and $colour_v$ = grey, then execute Section 3.4.7
  4. If $C_{id}$ = -1 and $colour_v$ = black, then $C_{id}$ = v; colour = blue.
  5. Else if colour = blue, then $C_{id} = C_{id} + v$; colour = grey.
  6. If BackupGW = -1 and Cid $\neq$ -1 and $colour_v$ = grey, then:
  7. Compute the Backup Gateway Selection Score:
     $\mathbf{BGSS_v} = \boldsymbol{\alpha}.\left(\frac{\mathbf{E_v}}{\mathbf{E_{max}}}\right) + \boldsymbol{\beta}.\left(\frac{\mathbf{1}}{\mathbf{d_{u,v}}}\right) + \boldsymbol{\gamma}.\left(\frac{\mathbf{S_v}}{\mathbf{S_{max}}}\right) + \boldsymbol{\theta}.\left(\frac{\mathbf{1}}{\lceil \mathbf{v_u} - \mathbf{v_v} \rceil}\right)$
  8. Set BackupGW = v for the node with the highest score.
iii. Calculate Degree of Cohesion (Executed by All Candidate Cluster Heads)
  1. $DC = \frac{1}{|N_u|}\sum_{j\in N_u}\left(\alpha.\frac{\min(S_u, S_j)}{\max(S_u, S_j)} + \boldsymbol{\beta}.\left(\frac{\mathbf{1}}{\mathbf{d_{u,j}}}\right) + \right.$
     $\boldsymbol{\gamma}. \mathbf{EuEu+Ej+}\boldsymbol{\theta}. \mathbf{1vu-vv}-\delta.\ Mu$
  2. Broadcast DC to 2-Hop Neighbors
iv. Upon Receiving Messages from Candidate Cluster Heads (CCH) within 2-Hop Neighbors (Executed by Candidate Cluster Heads Only)
  1. For each $v \in CCH$, if $\max(DC_v) = DC$, then: Set color = black; $C_{id}$ = id.
  2. Broadcast CH Message to Neighbors.
v. Upon Receiving Neighborhood Information from Candidate Gateways (CG) (Executed by Cluster Heads Only)
  1. Add id to CG.
  2. Split $C_{id}$ and add them to $CH_g$.
vi. After Receiving Neighborhood Information from All Candidate Gateways (CG) in Its Neighborhood (Executed by Cluster Heads Only)
  1. $CH_{Covered} = \emptyset$.
  2. $CH = \cup_{g \in CG} CH_g$.
  3. While $CH_{Covered} \neq CH$:
  4. For each $g \in CG$:
  5. Calculate $CH_{diff} = CH_g - CH_{Covered.}$
  6. Select id = $\max(|CH_{diff}|)$.
  7. Update $GW_{selected} = GW_{selected} \cup$ id.
  8. Update $CH_{Covered} = CH_{Covered} \cup CH_{g.}$
  9. Broadcast GWselected.
vii. Upon Receiving Gateway Selection Message (Executed by Candidate Gateways Only)
  1. If id $\in GW_{selected}$, then set colour = red and gold (primary gateway).
  2. Else if id $\notin GW_{selected}$ and BackupGW = -1, then set BackupGW = id; colour = blue (backup gateway).
viii. When a Clustered Node u Did Not Receive a Beacon Message from Its CH for Continuous Three Beacon Intervals (Executed by All Nodes)
  1. colour = white
  2. $C_{id}$ = -1
  3. BackupGW = -1
  4. For each $v \in N_u$:
  5. If dir = $dir_v$ and $colour_v$ = black, then:
  6. $C_{id}$ = v; colour = blue; exit.
  7. If dir = $dir_v$ and $colour_v$ = grey, then:
  8. Set colour = cyan; exit.
  9. Set colour = yellow and reinitiate Sections 3.5.3 and 3.5.4.
ix. Upon Failure of Primary Gateway (Executed by All Nodes)
  1. If colour = red and gold and BackupGW $\neq$ -1, then:
  2. Promote BackupGW as the new primary gateway.
```

3. Broadcast the new primary gateway selection message.
4. After promoting the backup gateway, recompute BGSS to select a new backup gateway.

## V. RESULT AND ANALYSIS

### a. Simulations Configuration

Table 2 Lists of the simulation parameters. The simulation was run for 2 hours. The transmission range of a vehicle was limited to 250 meters. For the warning messages, the region of interest was considered to be 5 km from the place of incident and period of validity of the message to 30 minutes.

**Table 2: Simulation Parameters.**

| **Parameter** | **Value** |
|---|---|
| Total No. of vehicles injected | 1000 |
| No. of lanes per direction | 4 |
| No. of vehicles per km per direction | 0-15 (Sparse), 16-30 (Average), 31-50 (Dense) |
| Beacon interval | 100 ms (Sparse), 150 ms (Average), 300 ms (Dense) |
| Transmission range | 250 m |
| MAC Protocol standard | IEEE 802.11p |
| Propagation model | Two-Ray Ground |
| Vehicle speed | 7 m/s to 27 m/s |
| Simulation time | 2 h |
| Lifetime for message | 30 min |
| Region of interest | 5 km from the place of incident |

A representative of the simulation run for a length of the road of 500 m is done for all two situations. The simulation ran in an average traffic situation, dense traffic situation in a sparse traffic situation.

### b. Results Analysis

This section presents the analysis of the results for the performance evaluation metrics.

#### i. Cluster Stability

The proposed technique achieves cluster stability by generating clusters with vehicles having similar speeds and selecting cluster heads with high cohesion. This reduces the number of times vehicles change their cluster state. In average traffic, over 80% of vehicles remain in their initial clusters for a significant duration, while in sparse traffic, this rate is 71%. On average, vehicle cluster states change 3-4 times, with a maximum of 10 changes during simulations.

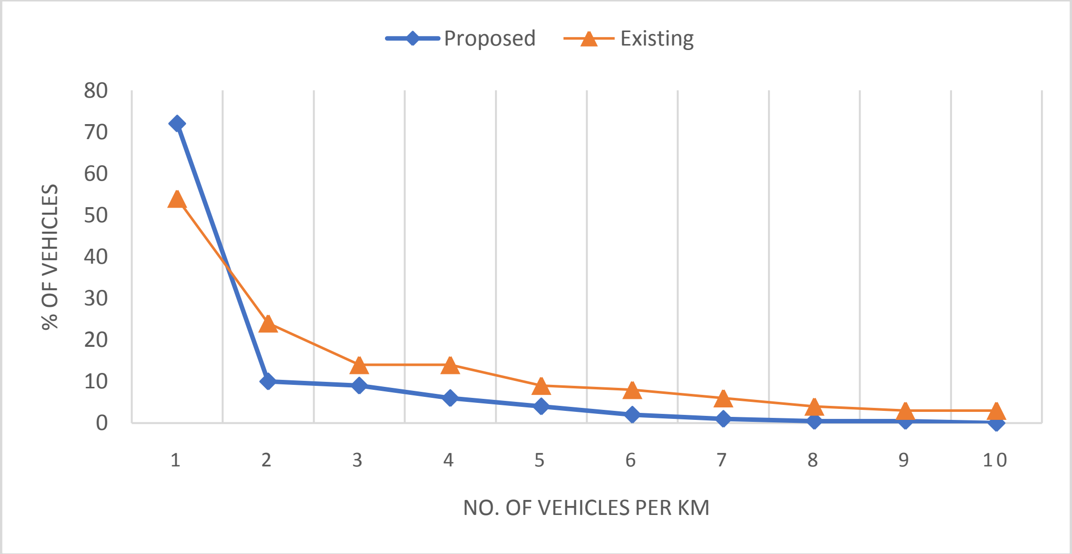

**Figure 2a: Cluster Stability for Dense**

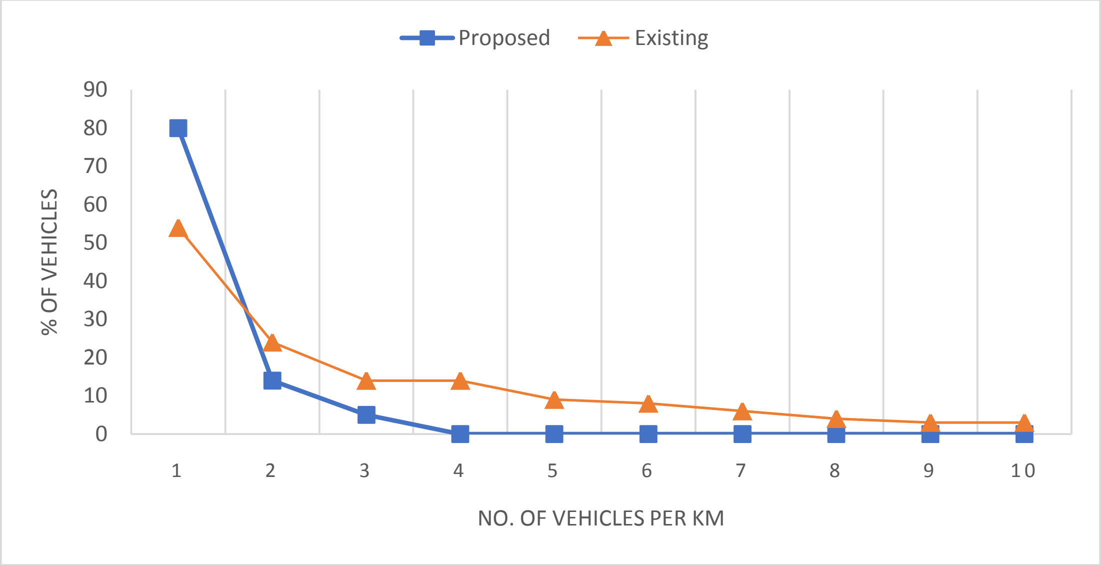

Figure 2b: Cluster Stability for Sparse

### ii. End-to-end Delay

The proposed technique significantly outperforms existing methods in terms of message delivery delay within a 5 km range. This is primarily due to its effectiveness in reducing broadcast storms, employing efficient clustering techniques, and utilizing backup gateways. The combined effect of these factors results in faster and more reliable message dissemination within the specified region.

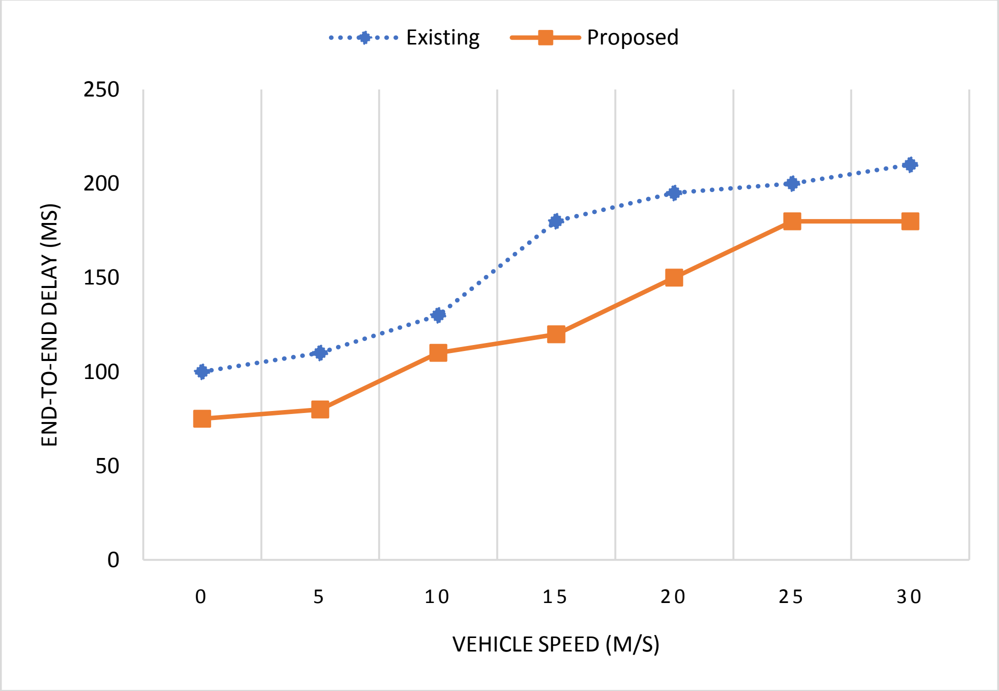

Figure 3: End-to-end Delay Versus Vehicle Speed.

### iii. Packet Loss Ratio

Figures 4.3 displays the Packet Loss Ratio (PLR) when the number of cars per kilometer increases. Due to the drop-in number of rebroadcasting vehicles PLR is minimal and reaches around maximum 2% only.

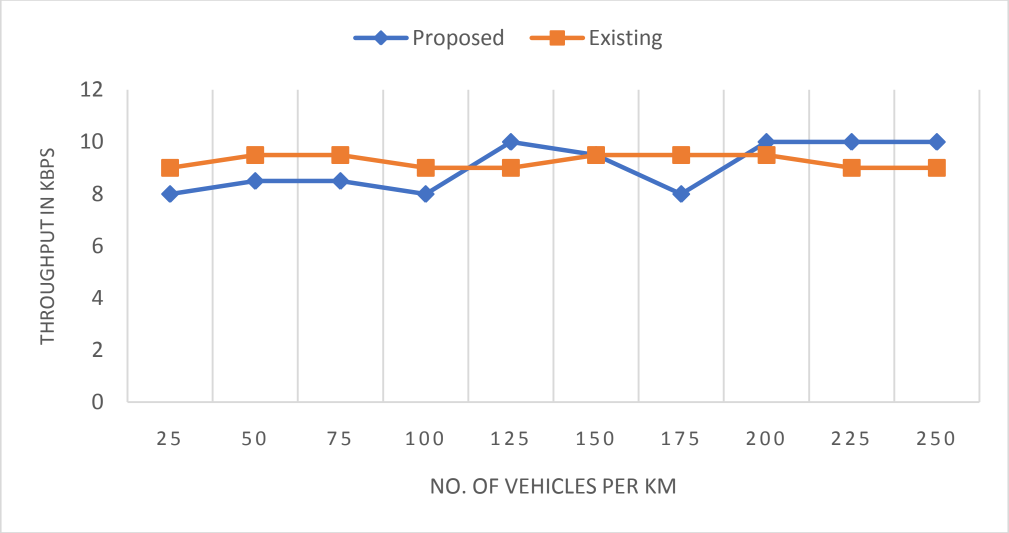

**Figure 4: Packet Loss Ratio Versus Vehicle Density.**

### iv. Packet Delivery Ratio

The proposed technique demonstrates high message reachability in both sparse and dense traffic scenarios. In sparse scenarios, a store-and-forward mechanism is used to overcome intermittent connectivity, achieving a reachability rate of 88-96%. In dense scenarios, a near-perfect reachability of 99-100% is achieved. This highlights the effectiveness of the proposed approach in ensuring widespread message delivery across various traffic conditions.

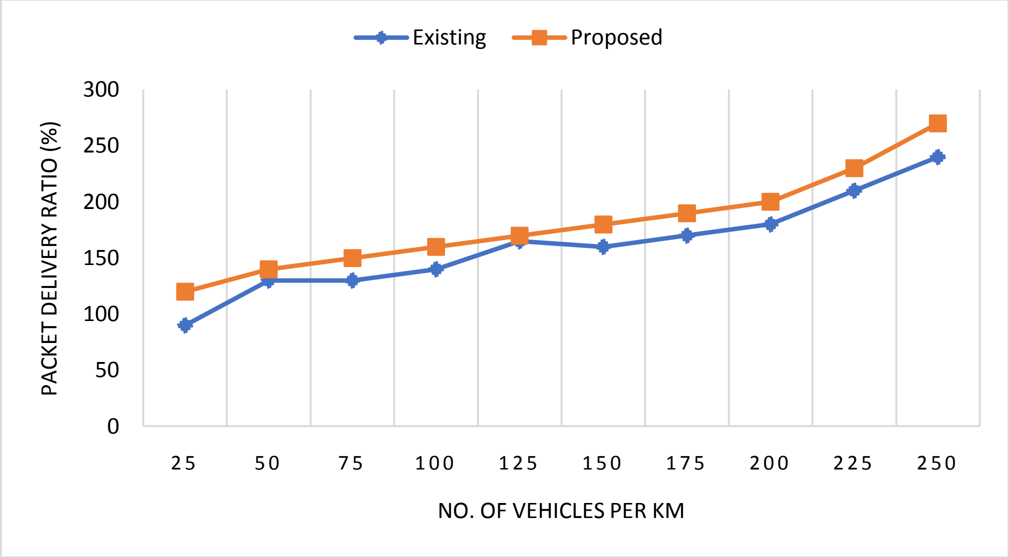

**Figure 5: Packet Delivery Ratio Versus No. of Vehicle per km.**

### v. Throughput

The proposed technique demonstrates higher throughput compared to existing methods. This is attributed to the faster message distribution resulting from reduced broadcast storms, efficient clustering, and backup gateways. In terms of packet transmission, throughput increases with an increase in the number of packets transmitted. The figure compares the throughput from the source vehicle to all vehicles within a 5 km range, highlighting the superior performance of the proposed technique in achieving higher throughput rates.

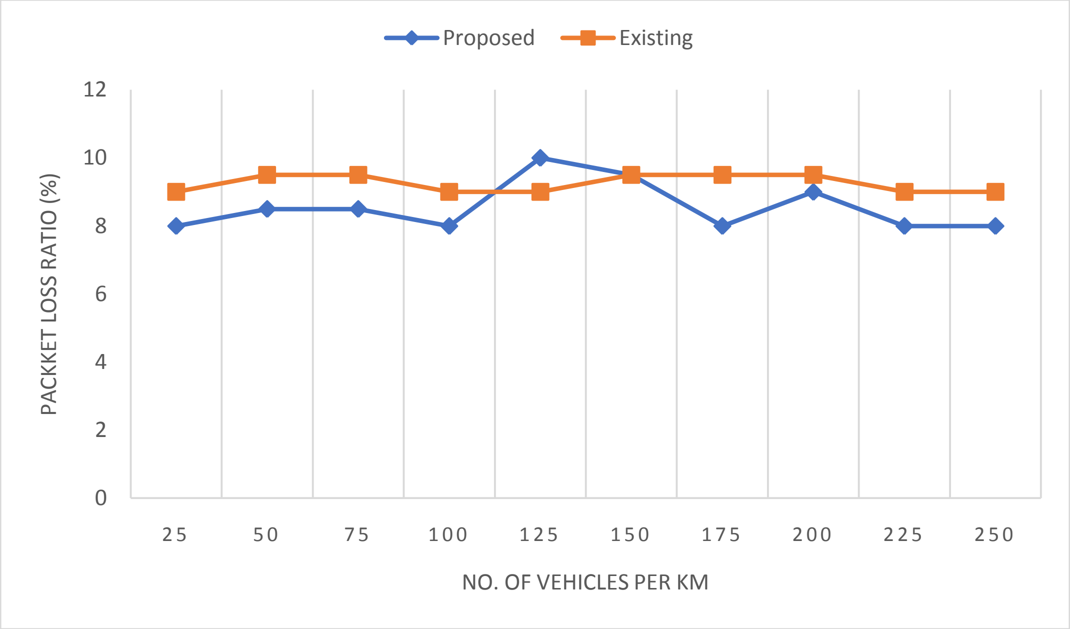

Figure 6: Throughput No. of Vehicle per km.

## VI. CONCLUSION

The proposed algorithm addresses broadcast storm problems and inconsistent connectivity in VANETs by clustering vehicles and selecting a small number of forwarders. Vehicles join clusters based on their cohesiveness, determined by relative mobility. Cluster heads are selected using a dominating set, while cluster gateways and backup gateways are chosen based on set coverage. The algorithm ensures cluster head stability by allowing temporary un-clustering if alternative gateways are available. This approach significantly reduces broadcast storm, as evidenced by a substantial drop in packet loss and collision ratios. The message reachability in average and dense scenarios is high, reaching 99-100%.

## VII. RECOMMENDATIONS

The proposed research can be extended to include additional technologies such as IoT and MANET, and should also be studied in a real-time scenario. Security issues like Black Hole Attack, Warm Hole Attack, and Gray Hole Attack should be further investigated to enhance the scheme's reliability.